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ENVIRONMENTAL AND HEALTH HAZARDS BULLETIN ON BENZENE

HAZARDOUS CONTAMINANTS TECHNICAL COMMITTEE

HCP-78-3

October 1978

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Ministry
of the
Environment

ntario

The Honourable
Harry C. Parrott, D.D.S.,
Minister

K.H. Sharpe,
Deputy Minister

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ENVIRONMENTAL AND HEALTH HAZARDS BULLETIN

ON

BENZENE

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This bulletin has been prepared primarily as a ready reference for persons engaged in environmental pollution control. It is meant to provide information relative to the hazards involved in the conduct of normal investigations. Where detailed assessments are planned reference should be made to the literature cited in this brochure.

ORGANIC COMPOUNDS WORKING GROUP

BENZENE

Introduction

Benzene and other light aromatic hydrocarbons have been listed in 1976 by the Hazardous Substances Committee of MOE as one of several groups of potentially hazardous environmental contaminants in Ontario. Study of their properties and health effects was assigned high priority, as part of the Province's Hazardous Contaminants Programme. A detailed background document, commissioned by the Air Resources Branch of MOE, regarding the above aspects of light aromatic hydrocarbons is now available for perusal at each Regional Office of MOE. It confirms the relatively high hazard potential of benzene in Ontario, based on its substantial usage, significant environmental release potential and serious adverse health effects, particularly on exposure to high local concentrations and long-term exposure to lower levels.

The present brochure is the first of a planned series of similar ones summarizing information on other high priority hazardous contaminants. It should serve as a handy reminder or checklist of some important physical properties, uses, potential hazards and safety precautions regarding the handling, storage, and disposal of benzene.

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BENZENE

Description

Benzene is a volatile colourless liquid aromatic hydrocarbon which is highly flammable and which has a characteristic odour. (Rubber Cement)

Synonyms - Benzol
- Coal Tar Naphtha
- Phenyl Hydride

Important Properties - Boiling point 80°C
- Flash point -11°C (Closed Cup)
- Auto Ignition point 538°C (In Air)
- Specific gravity 0.88 g/cm^3
- Vapour density 2.7 (air = 1)
- Solubility in water 0.82 g/l
@ 22°C
- Odour threshold : 4.68 ppm

References - UTS report "Environmental Aspects of Selected Aromatic Hydrocarbons in Ontario." Report No.HCP1-78, Sept/78
- Handbook Physics and Chemistry

BENZENE

Hazards

To humans - HIGHLY TOXIC

- Route of entry (a) inhalation
  (b) through injured skin
- Skin irritation
- Narcosis
- Respiratory paralysis
- Bone marrow depression
- Leukemia on long exposure

Physical - Fire

- Explosion

Environmental - Water supply contamination

- Fish tainting
- Toxic to aquatic organisms
- Contributes to photochemical smog

References - MCA Chemical Safety Data Sheet SP-2

- UTS Report "Environmental Aspects of Selected Aromatic Hydrocarbons in Ontario" Report No. HCP-1-78, Sept./78
- Handbook of Industrial Toxicology

BENZENE

Precautions

Spills - provide containment

- absorb and dispose
- no fire, automobiles etc. where concentrations in flammable or explosive range
- avoid inhalation
- avoid skin contact - eyes
- entry into tanks should be made in accordance with required safety rules
- non-ferrous tools as required in refinery should be used to avoid sparks.

BENZENE

Entry Into Environment

Storage - Tank Breathers

This is probably the major source of entry into the environment. Storage losses in Ontario are estimated at 1.125 Gg/yr (1125 tonnes/yr)

Production - Process effluents
- Pressure relief valves
- Rupture discs

Leaks Equipment - Pumps, seals, valves, piping

Evaporation - In production
- In use of products

Gasoline - Spillage
- Evaporation
- Breathers

Spills - Derailments
- Tank Wagons
- Ruptured Drums; Pipes, etc.

BENZENE

Sampling & Analysis

Sampling

- Ambient Atmosphere
    - Grab samples in plastic bags
    - Adsorbent cartridges (Tenax GC)
    - Passive samplers

CONTACT AIR RESOURCES BRANCH REGARDING METHODOLOGY

- Water
    - Solvent extraction
    - Head space analysis
    - Inert gas stripping

CONTACT TRACE CONTAMINANTS LABORATORY REGARDING METHODOLOGY

Analysis

Gas chromatography with flame ionization detection.

Emergency Sampling

Perform as dictated by circumstances

BENZENE

Standards & Criteria

- Threshold Limit Value 10 ppm
  (ACGIH 1974) 32 mg/M^3
  Ref - Industrial Toxicology - Plunkett

- Acute poisoning - 3000 ppm in air v/v

  Ref. MCA Chemical Safety Data Sheet SD-2

- Occupational Exposures
  Maximum allowable limit
  8 hour average - 10 ppm

  Ref. Ontario Ministry of Labour

- Emission standard (point of impingement)
  half hour average 3 ppm (10 mg/m^3)under review

  Ontario Ministry of Environment

BENZENE

Producers & Users

Producers - Petroleum refineries

- Petrochemical plants
- Coking and steel plants
- Estimated production capacity in Ontario (1978 - 470 Gg/yr - 470,000 tonnes)

Uses

- Blended into gasoline in form of reformate
- Synthesis of petrochemicals such as ethylbenzene styrene, phenol, etc.
- Solvent in rubber, plastic paint and specialty chemical industries.

References - UTS Report "Environmental Aspects of Selected Aromatic Hydrocarbons in Ontario". Report No. HCP-1-78, Sept./78. (See Appendix).

BENZENE

Storage and Handling

- Protection against physical damage
- Outside or detached storage is preferable
- Inside storage in standard flammable liquid storage room

Guideline for Ref. Chemical Products Storage OME 1978

MCA Chemical Safety Data Sheet SD-2

BENZENE

Disposal

Liquids - If water content is less than 20% liquids can be burned in approved incinerators.

Solids - Benzene in combustible solids can also be incinerated.

- In non-combustible solids it can be disposed of in secure landfills.

APPENDIX

- USES AND MARKET FORECAST -

(Excerpts from Report No. HCP-1-78:
"Environmental Aspects of Selected
Aromatic Hydrocarbons in Ontario").

8.3.3 USES OF BENZENE (EXTRACTED)

For many years the largest outlet for benzene was in blends with gasoline. Benzene was used with gasoline because of its high anti-knock value and its tendency to lessen starting difficulties. During World War II the use of benzene in the chemical industry expended rapidly. With the great rise in the demand and price of benzene for chemical manufacture during the post war years, the use of benzene in motor fuel blends has almost ceased in North America. At the present time chemical usage accounts for almost all of the benzene consumed in North America.

Figure 8-1 shows the products derived from benzene. The major products are seen to be ethylbenzene, cyclohexane, cumene, alkylbenzenes, maleic anhydride, chlorobenzene, and nitrobenzene. In the Canadian petrochemical industry, only ethyl benzene, styrene, cumene, cyclohexane, and maleic anhydride are manufactured as primary derivatives of benzene, with only ethylbenzene and styrene being manufactured in Ontario.

An estimate of the end-use pattern for benzene in Canada in 1977 is presented in Table 8-6. The manufacture of ethylbenzene to produce styrene is the major use of benzene. At the present time all ethylbenzene produced from benzene in Canada is manufactured in Ontario by two

FIGURE 8-1 USES OF BENZENE AND DERIVATIVES

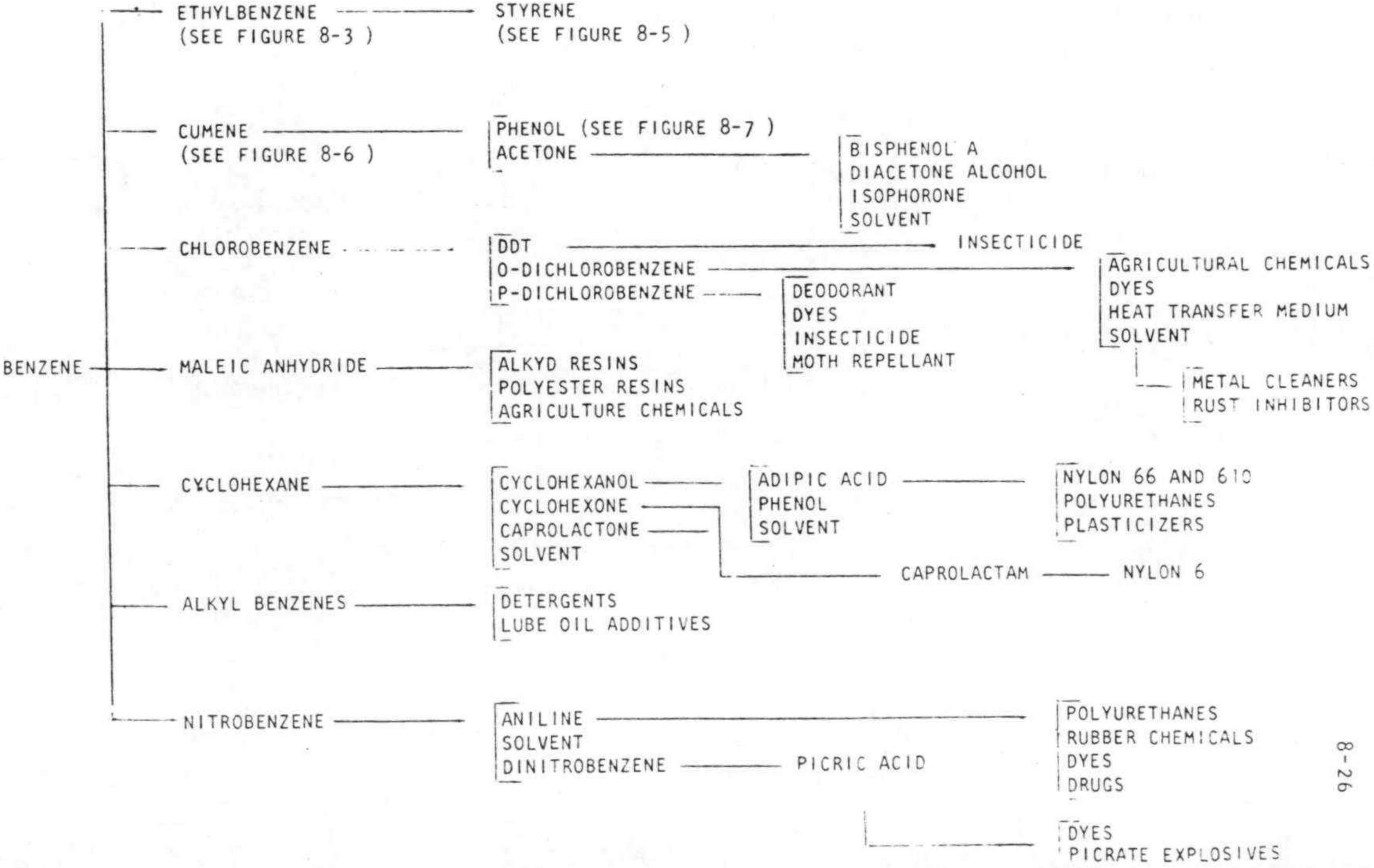

TABLE 8-6

ESTIMATED END-USE PATTERN FOR BENZENE PRODUCED IN CANADA IN 1977

USE	% OF PRODUCTION
Ethylbenzene (Styrene)	28
Cumene	6
Cyclohexane	14
Maleic Anhydride	1
Miscellaneous	12
Exports	46
Inventory Change	-7
	100

companies - Polysar Ltd. and Dow Chemical Co. of Canada, both located in Sarnia. The combined ethylbenzene production capacity of these two companies is about 200 Gg/annum. However, Dow Chemical of Canada may use some of its production facilities to produce glycols instead of ethylbenzene (17), so in some years total styrene production may be as low as 130 Gg/annum.

Cumene and cyclohexane are both manufactured by Gulf Oil Co. of Canada, Montreal East, Quebec. Maleic anhydride is manufactured by Monsanto Ltd. at La Salle, Quebec. Production of these chemicals account for about 90 Gg of benzene consumption per annum.

Table 8-7 presents a breakdown of uses by various industries as reported by Statistics Canada (16, 18-21). The only year for which figures are complete (1974) show a total consumption in these industries of 97 Gg of benzene. The benzene used by petroleum refineries is probably used as a gasoline blend, but this is not certain. The 0.89 Gg of benzene used by paint and varnish manufacturers is almost certainly used as a solvent.

The largest uses of benzene are the manufacturers of organic chemicals. However, as there are not more than three major producers for any of the high volume benzene derivatives produced in Canada, Statistics Canada does not release production figures for confidentiality reasons. Thus the 71 Gg of benzene consumed in this industrial category is probably used in the manufacture of detergents and surfactants, as a solvent or carrier, and in the manufacture of speciality chemicals for the rubber and plastics industries.

The miscellaneous chemical industries category includes several hundred small companies producing a variety of different products. Benzene usage in this category is probably as a solvent in printing inks, or as a precursor or solvent for specialty chemicals in the production of disinfectants, pesticides, polishes, adhesives and cements. Benzene usage in the plastics and synthetic resins industry is likely as a solvent and carrier in polymerization processes.

8.3.4 MARKET FORECAST

Table 8-8 presents a forecast of benzene supply and demand in Canada to 1990, and average annual consumption growth rates.

Current expansions which are either just completed or nearing completion in Ontario (mainly at Sarnia locations) are estimated to fulfill Ontario (and most Canadian) requirements through 1980. The Petrosar facility just completed at Sarnia came on-stream in late 1977, and will be fully operational in 1978. When fully operational, this facility will consume 27 Ml/day of Canadian crude oil to produce 165 Gg/annum of benzene and 125 Gg/annum of toluene and xylene mixture, as well as 1.27 Ml/day of gasoline. The bulk of the petrochemical output will be sold to the three major shareholders - Polysar Ltd., DuPont of Canada Ltd., and Union Carbide Canada Ltd. Some production will be sold to Shell Canada Ltd.

The Shell aromatics facility at Sarnia, currently producing around 33 Gg/annum of benzene, is being expanded to produce 100 Gg/annum of

TABLE 8-8

FORECAST FOR BENZENE SUPPLY AND DEMAND IN CANADA TO 1990

(All figures in Gg/annum)

	1977	1980	1985	1990
Capacity	540	750	885	965
Production	457	636	807	868
Domestic Consumption	282	422	625	777
Imports	nil	nil	nil	nil
Exports	209	214	182	91
Inventory Change	-34	nil	nil	nil

AVERAGE ANNUAL CONSUMPTION GROWTH RATES

1976 - 1980 = 14 %

1980 - 1985 = 8 %

1985 - 1990 = 4.5 %

1976 - 1990 = 8.5 %

benzene by 1978. Texaco Canada Ltd.'s new refinery at Nanticoke is expected to produce about 40 Gg/year of benzene when fully on-stream in 1978. However, this extra feedstock may not have a large effect on the benzene market as Texaco may have to close its Port Credit aromatics facility until a market is found for the extra benzene capacity (22).

Polysar Ltd. has recently completed a plant to produce 320 Gg/annum of ethylbenzene and 270 Gg/annum of styrene. Some of the feedstock for this plant will come from the Petrosar facility.

A major shift in benzene end-use patterns can be expected if a new cumene plant is built in Canada. If a long-term contract can be negotiated with a U.S. phenol producer, a cumene plant may be built in Sarnia (5).

The Alberta Energy Resources Conservation Board have recently awarded a contract to a consortium known as the Petalta group (Alberta Energy Co. Ltd., Mitsubishi Chemical Co., Mitsubishi Corp., and Hudson's Bay Oil and Gas Co. Ltd.) to produce benzene and other liquid by-products from natural gas condensates. The Petalta group plan to build a $ 227 million plant in Saskatchewan that would produce 1.55 Ml/day (1.36 Gg/day) of benzene and 4.65 Ml/day of other liquid by-products from 7.5 Ml/day of pentanes-plus condensates (23). The project is expected to be completed by 1979-1980.

A long term possibility for benzene production is by manufacture from coal by liquifaction. Presently, technology is available to produce aromatics by coal liquifaction, but the process is still economically

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unfeasible. However, with crude oil prices expected to rise and with domestic natural gas and oil supplies dwindling, this process could become of major significance in the next 10-15 years.

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